

**PEAKING OF WORLD OIL PRODUCTION:
IMPACTS AND THE SCOPE OF
THE MITIGATION PROBLEM**

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**Roger H. Bezdek, Ph.D.
Management Information Services, Inc.
www.misi-net.com**

This Presentation

- **PEAKING OF WORLD OIL PRODUCTION**
- **LEARNING FROM THE PAST**
- **TRANSPORTATION FLEET LIFETIMES**
- **MITIGATION OPTIONS**
- **THREE MITIGATION SCENARIOS**

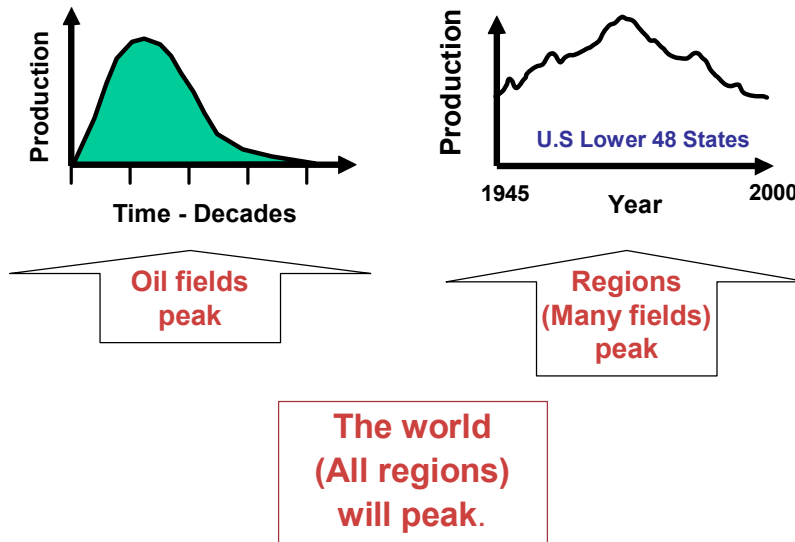


No, we're facing a liquid fuels crisis

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While some refer to the oil risks and challenges America faces as an “energy crisis,” this is misleading. We face the ominous prospect of crippling liquid fuel shortages and soaring prices.

Why will conventional oil production peak?



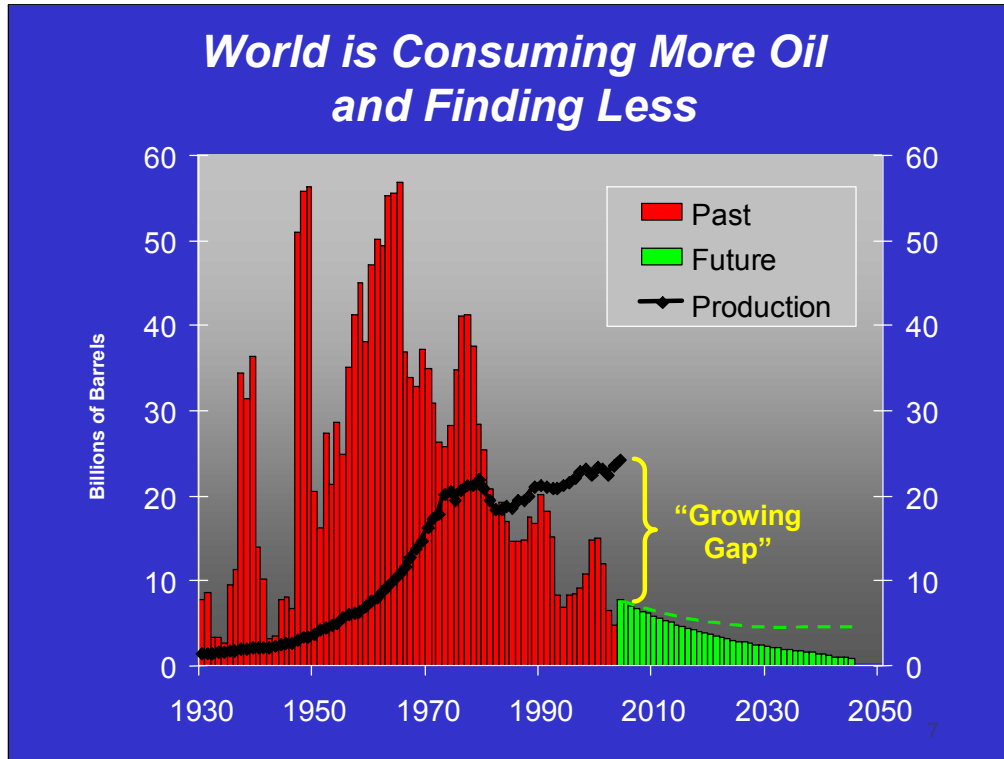
FUNDAMENTALS

Peaking is maximum production,
not running out.

It's a liquid fuels problem.

OBSERVATIONS

- **World oil demand is huge & growing.**
- **Most past peaking predictions were wrong.**
 - + Hubbert was right on the U.S. Lower 48
 - + Recent predictions may be right.
 - + Wrong isn't forever.
- **Why reconsider peaking now?**
 - **World oil consumption outstripping new discoveries**
 - **Extensive drilling worldwide - Large database**
 - **Advanced technology: Modern geology & 3D seismic**
 - **Many experts are pessimistic.**
 - **The economic consequences are huge.**



This shows the world situation.

- It is the most important slide I can show you.

Exxon deserves huge credit for publishing it with good data and revisions properly backdated to discovery.

- World discovery has been falling relentlessly for 40 years.

There is no good reason to expect the trend to change direction, so we can extrapolate it to indicate what is yet-to-find, shown in green. That might even be a bit optimistic.

- Consumption, shown in black, started to exceed discovery in 1981, and the gap is widening.

We now use about five or six barrels for every one we find.

- Take a good look : it says it all.

When?

No one knows for certain

<u>Forecast</u>	<u>Source</u>	
2006-2007	Bakhtari (Iran)	}
2007-2009	Simmons (U.S.)	
After 2007	Skrebowski (U.K.)	
2008	Campbell (Ireland)	
Before 2009	Deffeyes (U.S.)	
Before 2010	Goodstein (U.S.)	}
After 2010	World Energy Council	
2012	Weng (China)	
2016	Doug-Westwood (U.K.)	}
After 2020	CERA (U.S.)	
2031 or later	EIA (U.S.)	

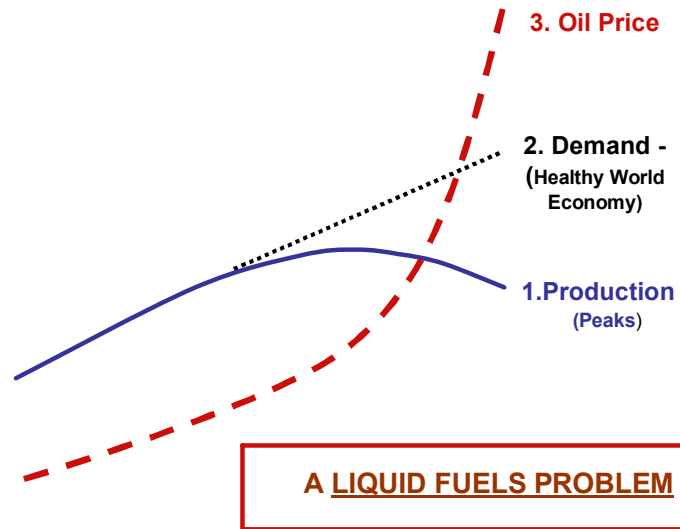
5 years

5-10 years

> 15 years

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LIKELY TRENDS NEAR WORLD OIL PEAKING

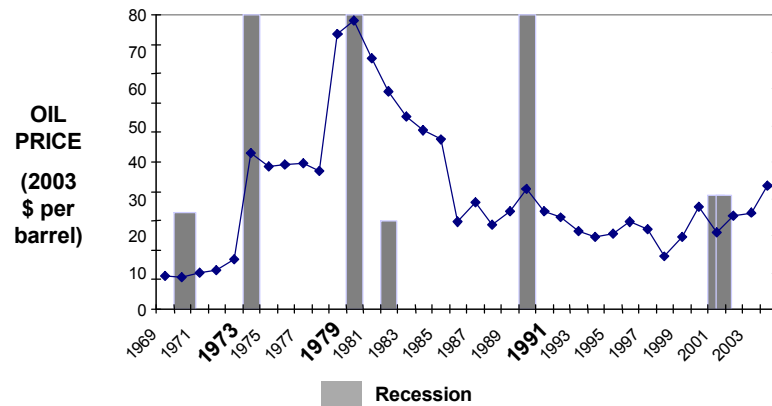


LEARNING FROM U.S. NATURAL GAS

- **Experts overestimated North American natural gas reserves & future production as late as 2001.**
 - National Petroleum Council - 1999
 - DOE EIA - 1999
 - Cambridge Energy Research Associates - 2001
- **U.S. natural gas production is now in decline.**

- Natural gas & oil geology are similar.
- If wrong on natural gas, what's the risk on oil?

OIL PRICE INCREASES HAVE CAUSED U.S. RECESSIONS



Over 30 years, four recessions followed oil price spikes.

Experience: Two Oil Interruptions

- Impacts of world oil production peaking are exemplified by the 1973 & 1979 oil interruptions.

- + Inflation
 - + Unemployment

- + Recession
 - + High interest rates

- 1973 & 1979 were relatively brief.
- World oil peaking impacts could last a decade or more.

The world has never faced a problem like oil peaking.

Remember the 1970s?
Stagflation. . . recession.
That was only a short-term disruption.



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In contrast, doing little or nothing subjects America to long-term energy supply disruptions and to potentially severe economic consequences.

U.S. OIL USE

- **U.S. 2003 consumption: ~20 MM bpd**
 - ~25% of world oil demand
 - ~Two thirds used in transportation
- **The U.S. transportation fleet**
 - + Very large
 - + Huge investment
 - + Evolves slowly



Details

CHARACERISTICS OF U.S. TRANSPORTATION FLEETS

Fleet	Size	Median Lifetime (Years)	Cost to Replace Half the Fleet (2003 \$)
Automobiles	130 million	17	\$1.3 trillion
Light Trucks, SUVs, etc.	80 million	16	\$1 trillion
Heavy Trucks, Buses, etc.	7 million	28	\$1.5 trillion
Aircraft	8,500	22	\$.25 trillion

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Transportation Equipment Changes

Efficiency improvements possible:

Large in some fleets, smaller in others,

BUT

Change is slow & expensive.

Fuel must be provided for existing fleets.

THREE MITIGATION SCENARIOS

- Scenario I - No action until peaking occurs
- Scenario II - Mitigation started 10 years before peaking
- Scenario III - Mitigation started 20 years before peaking

Assumptions:

- » All mitigation initiated immediately
- » Crash program implementation

Optimistic limiting case

MITIGATION OPTIONS

Focus: Technologies that can be implemented now for liquid fuels applications.....Commercial or near-commercial

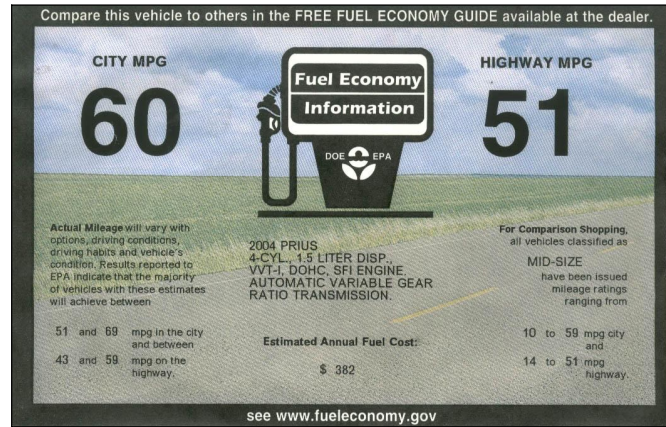
Options Considered:

- **Vehicle Fuel Efficiency**
- **Gas-To-Liquids (GTL)**
- **Heavy Oil / Oil Sands**
- **Coal Liquefaction**
- **Enhanced Oil Recovery (EOR)**

OPTIONS NOT INCLUDED

<u>Option</u>	<u>Reasoning</u>
- Nuclear	} Electric / Not liquid fuels
- Wind	
- Solar	
- Hydrogen.....	Neither ready nor economic
- Biomass.....	Not economic
- Shale Oil.....	Not commercial

Increased Vehicle Efficiency



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It will also examine how to increase U.S. transportation fuel efficiency,

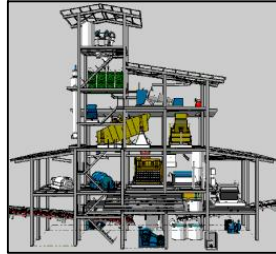
MITIGATION OPTIONS & ISSUES - I

VEHICLE FUEL EFFICIENCY

- Automobiles & light trucks (LDVs) are the largest liquid fuel consuming opportunity.
 - Diesel engines are up to 30% more efficient than gasoline engines.
 - Hybrids are 40% more efficient in small cars / 80% in medium cars.
 - Enhancements to existing technologies can also contribute.

Our savings estimates based on 30%, then 50% improvements

Coal, Oil Shale, Oil Sands, and Gas to Liquid Fuel Plants



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To produce the huge amount of alternative liquid fuels needed will require an enormous effort on the part of American industry, government, and the entire nation. American industry will have to build hundreds of new plants that utilize coal, oil shale, biomass, petroleum waste, and other carbon bearing feedstocks. They will be able to produce a broad variety of needed products, including liquid fuels for transportation, steam, methane, emissions-free electricity, hydrogen, and other chemicals and construction aggregate products.

In order to build the large number of plants required on a “crash program” basis, it will be necessary to standardize plant designs as much as possible and to build manufacturing facilities for the mass production of modular systems. Modular plants can be field-erected in months instead of the years that it now takes to build traditional field-fabricated processing plants.

MITIGATION OPTIONS & ISSUES - II

GAS-TO-LIQUIDS

- Now commercial & could be significant
- Must compete with LNG
- Non-U.S. resource

Our production estimates based on 2x current GTL projections

MITIGATION OPTIONS & ISSUES - III

HEAVY OIL / OIL SANDS

- Canada + Venezuela: 3-4 trillion barrels
- ~600 billion barrels economic
- Only part clean fuels - Canada: 0.6 of 1.0 MM bpd
- Current plans - Canada: 3 MM bpd synthetic oil by 2030
- Large energy input required
- Oils harder to refine
- Significant environmental problems

Our production estimates based on 2-2.5x current projections.

MITIGATION OPTIONS & ISSUES - IV

COAL-TO-LIQUIDS

- Now commercial / near-commercial.
- Cost: \$30-35/bbl
- Huge coal resource in U.S., elsewhere
- Liquids don't need refining

Our estimates based on five new 100,000 bpd production plants/year.

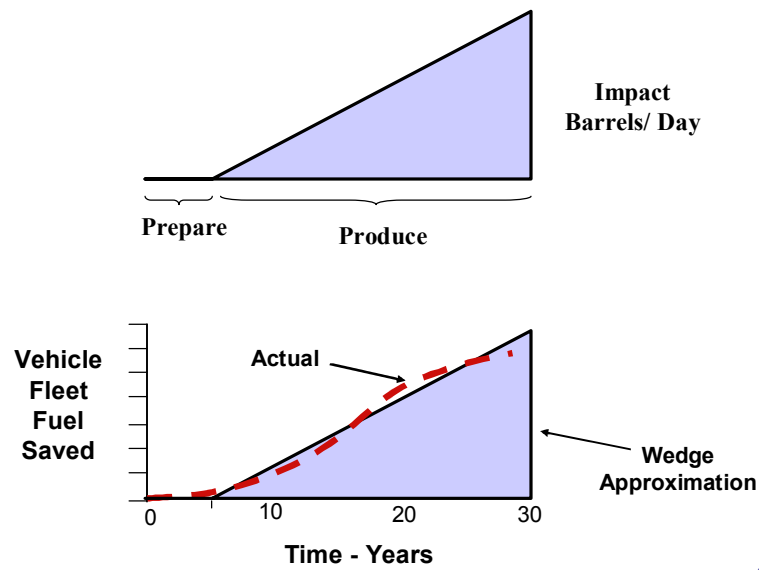
MITIGATION OPTIONS & ISSUES - V

ENHANCED OIL RECOVERY

- EOR has been utilized for decades.
- It's usually applied after primary and secondary recovery.
- It helps recover additional oil from reservoirs past peak production.






Our production estimates paced by CO₂ availability.

WEDGES USED TO SHOW MITIGATION



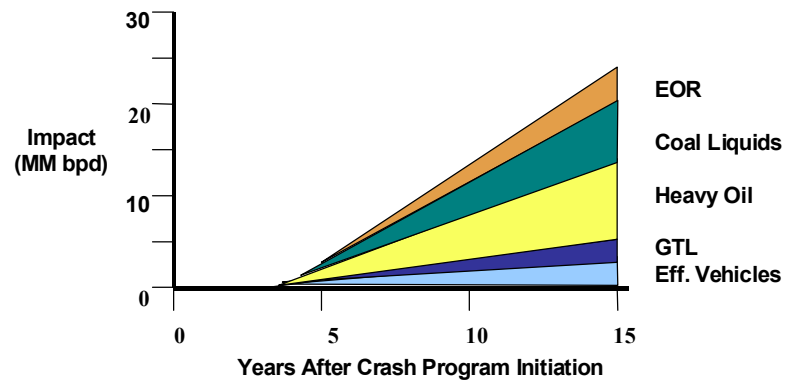
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WEDGES VALUES IN THIS STUDY

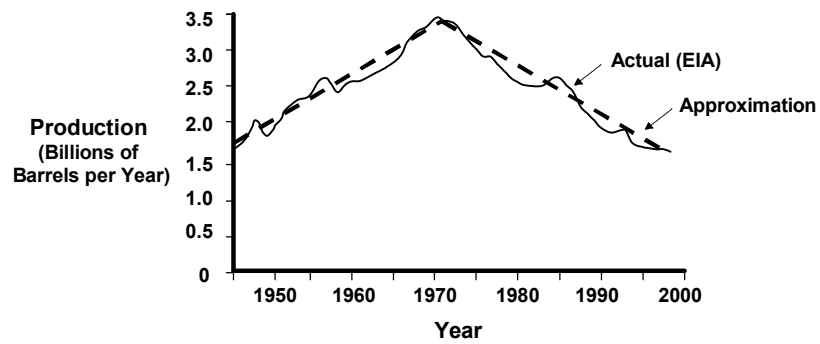
<u>Mitigation Option</u>	<u>Preparation Delay (Years)</u>	<u>Impact 10 Years Later (MM bpd)</u>
– Vehicle Efficiency	3	 2
– Gas-To-Liquids	3	 2
– Heavy Oils / Oil Sands	3	 8
– Coal Liquids	4	 5
– Enhanced Oil Recovery	5	 3

Potential contributions vary greatly.

SUM OF WEDGES

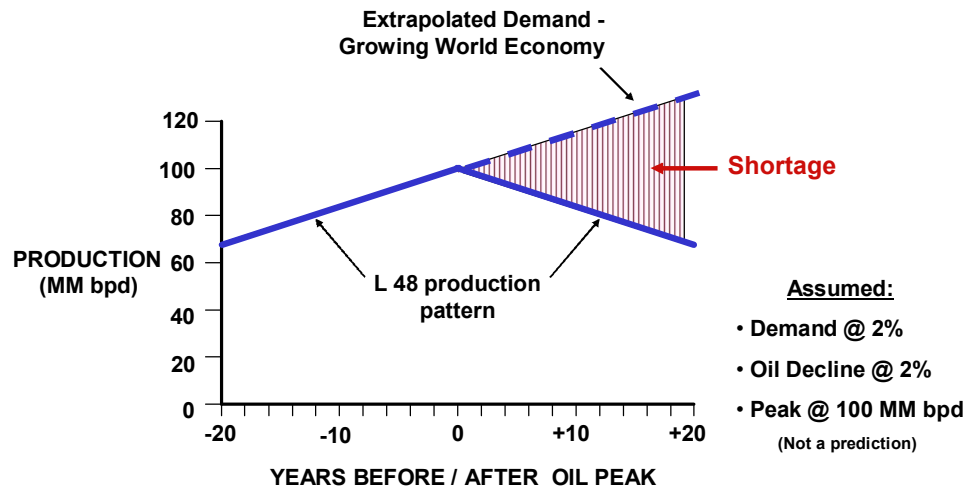


U.S. LOWER-48 OIL PRODUCTION PEAKED & DECLINED




A huge, complex & geologically varied oil province.
We used this pattern as a surrogate for the world.

**WORLD OIL SUPPLY & DEMAND:
LOWER 48 PRODUCTION PATTERN & EXTRAPOLATED DEMAND GROWTH**



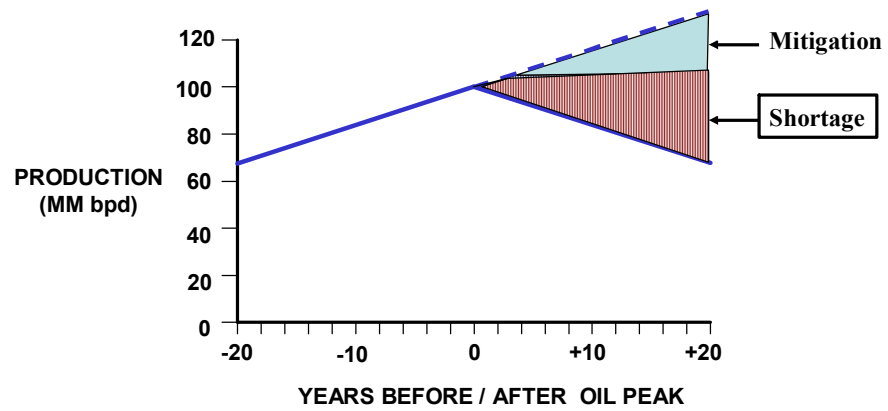
The only solution:

Start Early!

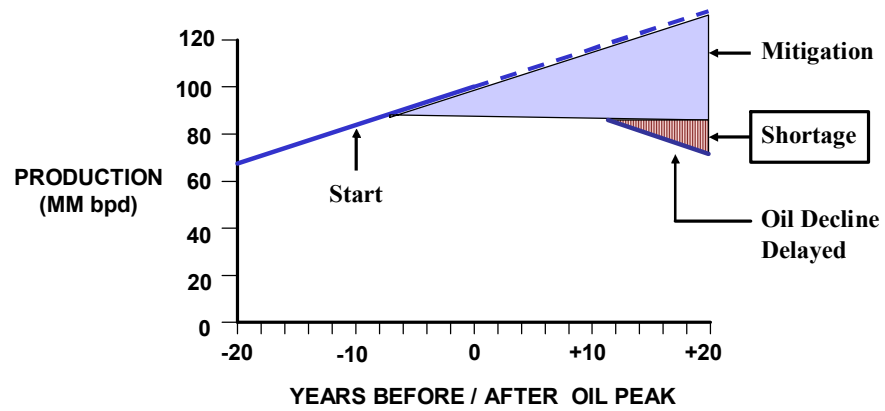


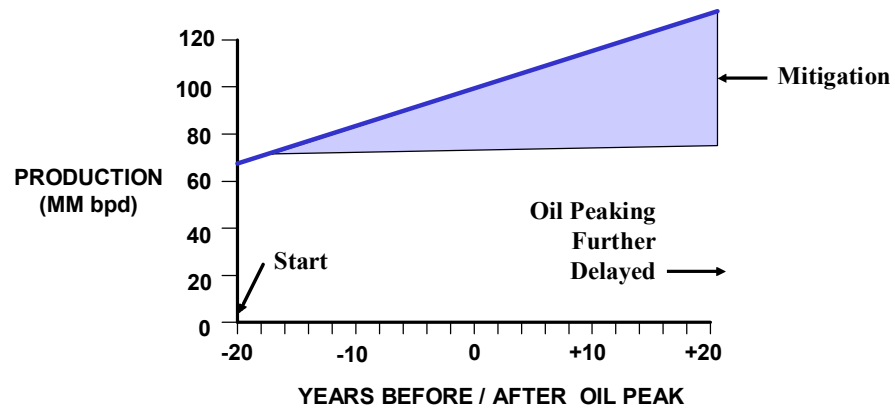
Look at the scenarios

SCENARIO I: MITIGATION @ PEAKING



SCENARIO II: MITIGATION 10 YEARS BEFORE



SCENARIO II: MITIGATION 20 YEARS BEFORE

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Scenarios Analysis Conclusions

Basis: Immediate crash program implementation

Scenario	Result
Wait for peaking	Oil shortages largest, longest lasting
Start 10 years early	Delays peaking; still shortages
Start 20 years early	Avoids the problem; smooth transition

No quick fix!

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Why so long to mitigate?

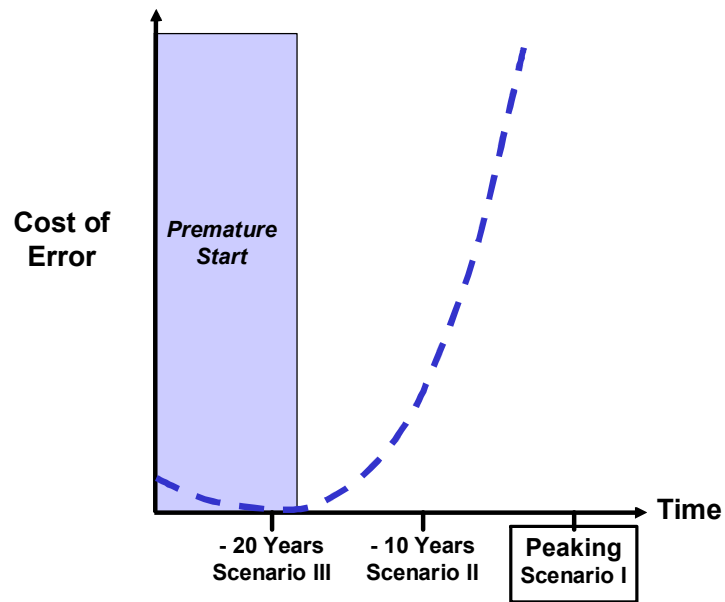
- Energy is inherently very large scale.
 - It's not computers or electronics
 - No magic bullets, only poison pills
- Long time to build capacity & savings
- Long lifetimes
- Inherently expensive

Options not in the study may contribute locally but will not change the overriding world problem.

SOME ISSUES

- Skilled workers & industrial capacity worldwide are in short supply for the level of effort described herein.
- Massive commercial crash programs are rare. Startup will almost certainly be much slower than assumed in this analysis.
- Some countries may delay, others will proceed rapidly with mitigation. China may have started (Canada, Venezuela).
- It is not clear how environmental protection will fare if there is widespread joblessness, high inflation & severe recession.

COST AS A FUNCTION OF START TIME - NOTIONAL

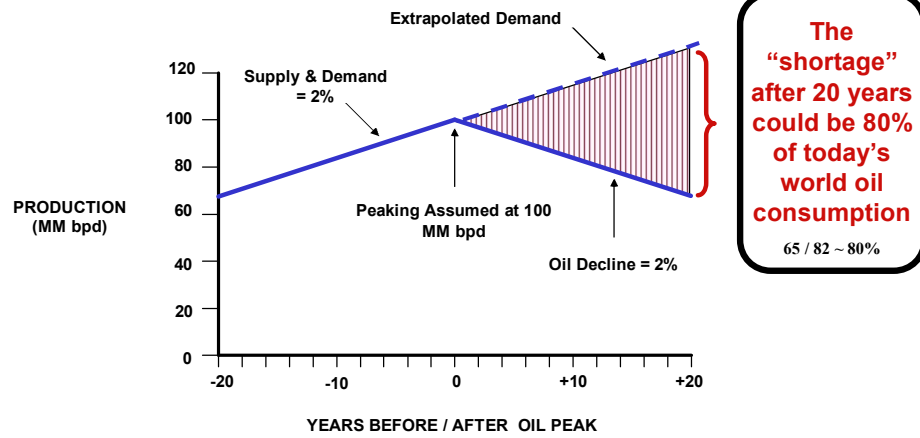


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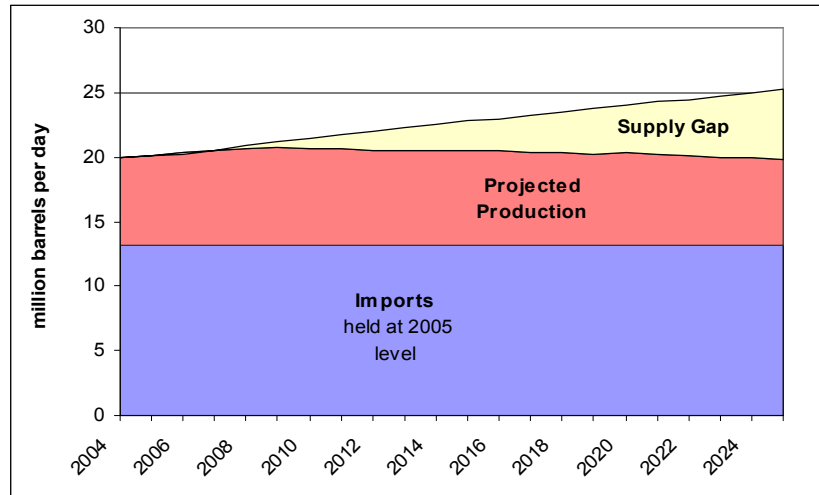
SUMMARY & CONCLUSIONS

- Oil peaking timing is uncertain.
 - It may be soon.
 - “Soon” is less than 20 years hence.
- It's a world liquid fuels problem.
- A number of mitigation technologies are ready.
- With timely mitigation, economic damage minimized.
- Prudent risk management argues for early action, not reaction after the fact.

LOOK AGAIN AT THE SHORTFALL



PRES. BUSH: "REDUCE OIL IMPORT DEPENDENCE"
FIRST THING TO DO: STOP DIGGING!



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It might happen again!

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THREE POLICY RECOMMENDATIONS

1. The federal government should increase vehicle fuel efficiency standards and initiate substitute liquid fuels mitigation options.
2. State and local governments should encourage smart growth, telecommuting, mass transit, and other transportation fuel efficiency options and facilitate and expedite the siting of substitute liquid fuels plants.
3. All levels of government should educate the public to the fact that we face a serious liquid fuels problem that will require controversial and unpopular measures to reduce demand and increase supply.